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MILITARY SPECIFICATION

FIBER, OPTICAL, (METRIC) GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements and characteristics of optical fibers for signal transmission. The fiber is defined as the core, cladding, and protective coatings applied during the fiber drawing process.

1.2 Classification. The optical fibers specified herein shall be categorized as follows:

1.2.1 Type. The type designation shall be defined by the mode volume of the optical fiber (see 6.4.18 and 6.4.20).

Type I. Multimode (MM).
Type II. Single-mode (SM).

1.2.2 Class. The class designation for multimode fibers shall be defined by the nature of refractive index profile, given by the profile parameter (g). The class designation for single-mode fibers shall be determined by the nature of their dispersion characteristics.

Multimode (Type I) fibers.
Class 1. Graded index: 3>g>1.
Class 2. Quasi-graded index: 10>g>3.
Class 3. Step index: g>10.
Class 4. Other.

Single-mode (Type II) fibers.

Class 5. Dispersion unshifted.
Class 6. Dispersion shifted.
Class 7. Dispersion flattened.
Class 8. Other.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Communications Electronics Command, ATTN: AMSEL-ED-TM, Fort Monmouth, NJ, 07703-5016 using the self-addressed Standardization Document Improvement Proposal (DD Form 1426 appearing at the end of this document or by letter.

1.2.3 Composition. The composition designation shall be defined by the composition of the optical fiber core and cladding (see 6.4.5 and 6.4.16)

A. Glass and Glass.
B. Glass and Plastic.
C. Plastic and Plastic.

1.2.4 Size. The size designation shall be defined by the diameter the optical core and cladding in micrometers (µm).

I. 4.0 - 8.5 µm (Range of nominal mode field diameter at 1550 ± 20 nanometers (nm)) /125 µm.
II. 8.5 -10 µm (Range of nominal mode field diameter at 1310 ± 20 nanometers (nm)) /125 µm.
III. 50/125 µm.
IV. 62.5/125 µm.
V. 100/140 µm.
VI. 200/230 µm.
VII. 400/430 µm.

1.2.5 Wavelength. The wavelength designation shall be defined by the primary wavelengths of operation of the fiber.

A. 850 nm.
B. 850 and 1300 nm.
C. 1300 nm.
D. 1300 and 1550 nm.
E. 1550 nm.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specification and standards. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

MIL-STD-129	- Marking for Shipment and Storage.
MIL-STD-202	- Test Methods for Electronic and Electrical Component Parts.
MIL-STD-454	- Standard General Requirements for Electronic Equipment.
MIL-STD-790	- Product Assurance Program Requirements for Electronic and Fiber Optic Parts Specifications.
MIL-STD-810	- Environmental Test Methods and Engineering Guidelines.
MIL-STD-1285	- Identification Marking of U.S. Military Property.
DOD-STD-1678	- Test Methods and Instrumentations, Fiber Optics.
MIL-STD-45662	- Calibration Systems Requirements.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the *DODISS* cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the document cited in the solicitation (see 6.2).

NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION (NASA)

NHB 8060.1 - Flammability, Odor and Offgassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion.

(Application for copies should be addressed to Office of Safety and Mission Quality, (code QR), NASA, Headquarters, Washington, DC 20546.)

ELECTRONICS INDUSTRIES ASSOCIATION (EIA)

EIA-440 - Fiber Optic Terminology.
• EIA-455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.
• EIA-455-13 - Visual and Mechanical Inspection of Fibers, Cables, Connectors and/or Other Fiber Optic Devices.
• EIA-455-20 - Measurement of Change in Optical Transmittance.
• EIA/TIA-455-28 - Method for Measuring Tensile Failure Point of Optical Waveguide Fibers.
• EIA-455-31 - Fiber Tensile Proof Test Method.
• EIA-455-46 - Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers.
• EIA-455-50 - Light Launch Conditions for Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurement.
• EIA-455-51 - Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Transmission Capacity.
EIA-455-54 - Mode Scrambler Requirements for Overfilled Launching Conditions to Multimode Fibers.
• EIA-455-58 - Core Diameter Measurement of Graded-Index Optical Fibers.
• EIA/TIA-455-59 - Measurement of Fiber Point Defects Using an OTDR.
• EIA/TIA-455-60 - Measurement of Fiber or Cable Length Using an OTDR.
• EIA-455-62 - Optical Fiber Macrobend Attenuation.
• EIA-455-63 - Optical Fiber Flexure Test.
• EIA-455-65 - Optical Fiber Flexure Test.
EIA/TIA-455-75 - Fluid Immersion Test for Optical Waveguide Fibers.
• EIA-455-78 - Spectral Attenuation Cutback Measurement for Single-Mode Optical Fibers.
• EIA-455-80 - Cutoff Wavelength of Uncabled Single-Mode Fiber By Transmitted Power.
• EIA-455-164 - Single Mode Fiber, Measurement of Mode Field Diameter by Far Field Scanning.
• EIA-455-167 - Mode Field Diameter Measurement-Variable Aperture Method in Far-Field.
EIA-455-173 - Coating Geometry Measurement for Optical Fiber Side-View Method.
• EIA/TIA-455-175 - Chromatic Dispersion Measurement of Optical Fibers by the Differential Phase Shift Method.
• EIA/TIA-455-176 - Measurement Method for Optical Fiber Geometry by Automated Grey Scale Analysis.
• EIA/TIA-455-177 - Numerical Aperture Measurement of Graded-Index Optical Fibers.
EIA/TIA-455-178 - Measurements of Strip Force Required for Mechanically Removing Coatings from Optical Fibers.

(Application for copies should be addressed to the Electronics Industries Association (EIA), 2001 Eye Street, NW, Washington, DC 20006.)

AMERICAN SOCIETY FOR TESTING OF MATERIALS (ASTM)

ASTM-E-595 - Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.

• Adopted by DoD

(Application for copies of ASTM Publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

(Non government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements for optical fibers shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Optical fibers furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.5 and 6.3). The provisions of 4.5.4 for retention of qualification are included in this requirement.

3.3 Product assurance requirements. The product assurance requirements of the optical fibers furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 with details specified in 4.1.2.

3.4 Materials (see 4.7.1). The fiber shall be constructed of material as specified (see 3.1). Raw materials selected for fiber manufacture shall be of a type and quality to assure compliance with the requirements of this specification, and shall be physically and chemically compatible for their intended use throughout the intended lifetime. All materials used shall be non conductive unless otherwise specified (see 3.1) and non nutrient to fungus. Where new and questionable material is being considered for use, the contractor shall furnish the toxicological data required to evaluate the safety of the material for the proposed use. Materials used in fiber construction shall not emit toxic or explosive fumes when exposed to flame, and shall have no adverse effect on the health of personnel when used for its intended purpose. Polyvinyl chloride (PVC) material shall not be used.

3.4.1 Recovered materials. Unless otherwise specified herein, all materials incorporated in the products covered by this specification shall be new. Products may be fabricated using raw materials produced from recovered bulk materials to the extent practicable if the intended use of the product is not jeopardized. The term "recovered material" means materials which have been collected or recovered from solid waste and reprocessed to become part of a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of partially processed, assembled, used or rebuilt products are allowed under this specification.

3.4.2 Materials for space applications. When specified, materials used in space flight applications shall meet the following additional material requirements.

3.4.2.1 Thermal vacuum outgassing. All non-metallic materials shall not exhibit greater than 1.0 percent total mass loss and shall not produce greater than 0.1 percent collected volatile condensable materials when tested in accordance with 4.7.2.5.1.

3.4.2.2 Odor. Non-metallic materials shall rate not greater than 2.5 when tested in accordance with 4.7.2.5.2.

3.4.2.3 Toxicity. When tested in accordance with 4.7.2.5.3, all non-metallic materials shall not exceed a total hazard index of 0.5.

3.5 Design and construction (see 4.7.2). The design, construction, and physical dimensions of the complete fiber shall be as specified herein and in the specification sheet (see 3.1).

3.5.1 Optical fiber. Optical fibers shall be sufficiently free of imperfections, inclusions and impurities other than dopants, to conform to the specified strength and optical transmission requirements. The optical fiber shall be coated with a suitable material to preserve the high pristine tensile strength of the fiber.

3.5.1.1 Splices. Unless otherwise specified (see 3.1 and 6.2), the fibers shall be splice-free. When specified, spliced fibers shall meet all dimensional, mechanical, and environmental requirements as unspliced fiber. The coating of spliced fibers shall be reconstituted in such a manner as to not change the diameter of the coating by more than the percentage specified (see 3.1). When specified, splice loss shall be as specified in the applicable specification sheet (see 3.1).

3.5.1.2 Geometry (fiber). The fiber geometry shall be as specified below.

3.5.1.2.1 Core diameter (for multimode fibers only). When tested in accordance with 4.7.2.1.1, the core diameter shall be as specified (see 3.1).

3.5.1.2.2 Mode field diameter (for single-mode fibers only). When tested in accordance with 4.7.2.1.2, the nominal mode field diameter and mode field diameter tolerance for single-mode fiber shall be as specified (see 3.1).

3.5.1.2.3 Core ovality (multimode fiber only). When tested in accordance with 4.7.2.1.3, the core ovality shall be as specified (see 3.1).

3.5.1.2.4 Cladding diameter. When tested in accordance with 4.7.2.1.4, the cladding diameter shall be as specified (see 3.1).

3.5.1.2.5 Cladding ovality. When tested in accordance with 4.7.2.1.5, the cladding ovality shall be as specified (see 3.1).

3.5.1.2.6 Core-to-cladding offset. When tested in accordance with 4.7.2.1.6, the core-to-cladding offset shall be as specified (see 3.1).

3.5.1.2.7 Coating diameter. When tested in accordance with 4.7.2.1.7, the coating diameter shall be as specified (see 3.1).

3.5.1.2.8 Overall coating concentricity ratio (OCCR). When tested in accordance with 4.7.2.1.8, the overall coating concentricity ratio shall be as specified (see 3.1).

3.5.1.3 Fiber mass/unit length (kg/km). When tested in accordance with 4.7.2.4, the fiber mass/unit length expressed as kilograms/kilometer shall be as specified (see 3.1).

3.5.2 Tensile proof. When tested in accordance with 4.7.2.2, the proof tested tensile strength of the fiber shall be as specified (see 3.1).

3.5.3 Mechanical strippability. When tested in accordance with 4.7.2.3, the fiber coating shall be mechanically strippable with commercially available stripping tools. There shall be no scratches, nicks, or inclusions in the stripped fibers or residual coating material on the stripped fiber which cannot be easily removed with a cotton pad or a wipe moistened with 90 percent concentration isopropyl alcohol. The maximum strip force shall be not less 1.8 N and not greater than 13.2 N.

3.5.4 Continuous lengths. Unless otherwise specified (see 3.1), the individual continuous lengths of finished fiber in each inspection lot shall be 1100 meters minimum. A spool shall contain no more than one continuous length of fiber.

3.6 Optical performance.

3.6.1 Change in optical transmittance. When tested in accordance with 4.7.3.1, the change in optical transmittance for the specified sample due to exposure of fiber to mechanical (environmental and physical) tests shall not be greater than 0.5 decibel (dB) for multimode fibers and 0.3 dB for single mode fibers.

3.6.2 Attenuation rate. When tested in accordance with 4.7.3.2, the fiber attenuation rate at the wavelengths of operation shall be as specified (see 3.1).

3.6.2.1 Attenuation uniformity. When tested in accordance with 4.7.3.3, there shall be no discontinuities in attenuation along the length of the multimode fiber greater than 0.2 dB and no discontinuities in attenuation along the length of the single-mode fiber greater than 0.1 dB, for the specified wavelength).

3.6.3 Numerical aperture (for multimode fiber only). When applicable (see 3.1) and when tested in accordance with 4.7.3.3, the numerical aperture shall be as specified (see 3.1).

3.6.4 Bandwidth (for multimode fiber only). When tested in accordance with 4.7.3.4, the fiber bandwidth at the wavelengths of operation shall be as specified (see 3.1).

3.6.5 Macrobend attenuation. When tested in accordance with 4.7.3.5, the macrobend attenuation shall be not greater than 0.5 dB for multimode fibers and the macrobend attenuation shall be not greater than 0.1 dB at 1300 ± 20 nm or 1.0 dB at 1550 ± 25 nm for single-mode fibers unless otherwise specified (see 3.1). The mandrel radius shall be 3.8 centimeters and the number of turns shall be 100.

3.6.6 Chromatic Dispersion. When tested in accordance with 4.7.3.6, unless otherwise specified, the zero dispersion wavelength of dispersion-unshifted single-mode fibers shall be 1310 ± 15 nm with a maximum dispersion value of 3.5 picoseconds per nanometer-kilometer (ps/nm-km) from 1290 to 1330 nm. When specified the dispersion at other wavelengths shall be as specified (see 3.1). The value of the dispersion slope at the zero dispersion wavelength shall be not greater than 0.1 ps/nm^2-km. The dispersion characteristics for all other single mode fibers shall be as specified (see 3.1). When specified, the multimode fiber zero dispersion wavelength and the dispersion slope at the zero dispersion wavelength shall be as specified (see 3.1).

3.6.7 Cut-off wavelength (for single-mode fibers only). When tested in accordance with 4.7.3.7, unless otherwise specified (see 3.1), the cut-off wavelength of dispersion unshifted single-mode fibers shall be between 1130 and 1330 nm. The cutoff wavelength for all other singlemode fibers shall be as specified (see 3.1).

3.6.8 Transient attenuation (for multimode fibers only). When specified, and when tested in accordance with 4.7.3.8, the transient attenuation for multimode fibers shall be as specified (see 3.1).

3.7 Environmental performance.

3.7.1 Thermal shock. When tested in accordance with 4.8.1, there shall be no cracking or melting of the fiber coating material and the change in optical transmittance shall not exceed the requirements of 3.6.1.

3.7.2 Temperature humidity cycling. When tested in accordance with 4.8.2, there shall be no swelling or softening of the coating material which causes the fiber diameter or length to exceed the specified dimensional tolerances (see 3.1). The change in optical transmittance shall not exceed the requirements of 3.6.1. The mechanical strippability requirements of 3.5.3 shall be met.

3.7.3 Temperature cycling. When tested in accordance with 4.8.3, there shall be no cracking or melting of the fiber coating material and the change in optical transmittance shall not exceed the requirements of 3.6.1.

3.7.4 Life aging. When tested in accordance with 4.8.4, the change in optical transmittance shall not exceed the requirements of 3.6.1. When returned to ambient temperature, visual inspection in accordance with 4.7.2 shall reveal no cracking or melting of the fiber coatings and the fiber coatings shall meet the mechanical strippability requirements of 3.5.3.

3.7.5 Fluid immersion aging. When specified (see 3.1), and when tested in accordance with 4.8.5, after removal of test specimens from the test fluid, the specimen shall meet all the requirements of 3.7.10.

3.7.6 Nuclear radiation resistance. When specified (see 3.1), and when tested in accordance with 4.8.6, the nuclear radiation resistance requirements shall be as specified (see 3.1).

3.7.7 Fungus resistance. When specified, and when tested in accordance with 4.8.7, polymeric fiber materials shall be in accordance with MIL-STD-454, requirement 4, for fungus-inert materials or shall meet grade I classification of MIL-STD-810, method 508. Care should be taken in handling tested fiber specimens to avoid altering of results or self contamination.

3.7.8 Torsion. When specified, and when tested in accordance with 4.8.8, the fiber shall not exhibit damage and the change in optical transmittance shall not exceed the requirements of 3.6.1.

3.7.9 Flexure. When specified, and when tested in accordance with 4.8.9, the fiber shall not exhibit damage and the change in optical transmittance shall not exceed the requirements of 3.6.1.

3.7.10 Dynamic tensile strength. When specified, and when tested in accordance with 4.8.10, the mean fracture strength after each period of aging shall be not less than 1.75 gigaPascals (GPa). The initial mean fracture strength shall be not less than 3.2 GPa. The Weibull modulus shall be reported.

3.7.11 Storage temperature. When specified, and when tested in accordance with 4.8.11, there shall be no cracking or melting of the fiber coating material and the change in optical transmittance shall not exceed the requirements of 3.6.1.

3.8 Identification marking. Unless otherwise specified in the acquisition document or in the specification sheet (see 3.1), the identification shall be applied to the outer surface of the fiber spool. Identification marking shall include indicators of the military specification number, specification sheet number, military Part or Identifying Number (PIN), manufacturer's code, and a four character date code indicating week and year. All markings shall be permanent and legible in accordance with MIL-STD-1285. When specified (see 3.1 and 6.2), a colored coating of the optical fiber shall be as specified (see 3.1 and 4.7.2).

3.8.1 JAN and J marking. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J" respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of military specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable detail specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the PIN except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable detail specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification, and the applicable specification sheets or detail specifications, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration No. 504,860 for the certification mark "JAN".

3.9 Workmanship (see 4.7.2). All details of workmanship shall be in accordance with high grade optical fiber manufacturing practice. Fibers shall be dimensionally uniform, free of lumps, kinks, splits, scraped or abraded surfaces and inclusions.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Product assurance program. A product assurance program shall be established and maintained in accordance with MIL-STD-790. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

4.1.3 Test equipment and inspection facilities. Provision for test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspections shall be the responsibility of the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662 and as specified herein.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.5).

b. Quality conformance inspection (see 4.6).

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in EIA/TIA-455.

4.4 Materials inspection. Materials inspection shall consist of certification, supported by verifying data, that materials used in fabricating the delivered fiber are in accordance with the requirements of 3.4 and as specified (see 3.1).

4.5 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production. Group qualification shall be as specified in 6.3.2.

4.5.1 Sample. A finished optical fiber sample shall be submitted for each fiber construction (see 3.1) for which qualification is desired (see 6.3.2). The sample size, unless otherwise specified (see 3.1), submitted shall be 7 each units of 1.1-km lengths with no splices (4.6.1.1).

4.5.2 Inspection routine. The samples shall be subjected to the qualification inspection specified in table I in the order shown. In cases where certain requirements and tests are applicable only when specified (see 3.1), these tests shall be conducted in the order shown when specified in the appropriate specification sheet (see 3.1). Tests which are not specified as applicable to a specific fiber construction shall not be conducted. All sample units shall be subjected to the inspection of group I. Specimens shall be cut from each sample unit in lengths at least as long as specified in table I. Test specimens from each sample unit shall be subjected to the tests of groups II and III of table I; however, each test specimen shall be subjected to only one group of tests in addition to group I.

4.5.3 Failures. One or more failures shall be cause for refusal to grant qualification approval.

4.5.4 Retention of qualification. To retain qualification, the manufacturer shall forward a report at 12- and 36-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall consist of:

a. A summary of the results of the tests performed for inspection of product for delivery (groups A and B), indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for. Summary shall be submitted at 12-month intervals.

b. A summary of the results of tests performed for qualification verification inspection (group C), including the number and mode of failures. The summary shall include results of all qualification verification inspection tests performed and completed during the 36-month period. If the summary of the test results indicated noncomformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

4.5.4.1 Failure to submit a report. Failure to submit the report within 60 days after the end of each 12 or 36-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 12 or 36-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification.

4.5.4.2 No production. In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during two consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of the optical fiber covered by each specification sheet to testing in accordance with the qualification inspection requirements.

4.6 Quality conformance inspection. Quality conformance inspection shall consist of the inspections and tests specified for group A inspection (table II), group B inspection (table III), and group C inspection (table IV).

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Unit of product. A unit of product shall be 1100 meters.

4.6.1.2 Production unit. A production unit shall consist of product defined by the sampling plan for which statistical group B sampling is used.

4.6.1.3 Specimen. A specimen shall be an individual length of fiber cut from the sample unit. Unless otherwise specified a minimum of the specimens shall be inspected and tested from each sample unit.

TABLE I. Qualification inspection.

Inspection	Requirement paragraph	Test paragraph	Applicable test document	Specimen length
Group I				
Visual and mechanical inspection	3.4, 3.5, 3.7 3.8, 3.9,	4.7.2	EIA-455-13 EIA/TIA-455-60	7 @ 1100 m 1/
Core diameter	3.5.1.3.4	4.7.1.1.4	EIA-455-58	2/
Mode field diameter	3.5.1.3.2	4.7.1.1.2	EIA-455-167 or EIA-455-164	2/
Core ovality	3.5.1.3.3	4.7.1.1.3	EIA/TIA-455-176	2/
Cladding diameter	3.5.1.3.4	4.7.1.1.4	EIA/TIA-455-176	2/
Cladding ovality	3.5.1.3.5	4.7.1.1.5	EIA/TIA-455-176	2/
Core-to-cladding offset	3.5.1.3.6	4.7.1.1.6	EIA/TIA-455-176	2/
Coating diameter	3.5.1.4.1	4.7.1.2.1	EIA-455-173	2/
Overall coating concentricity ratio	3.5.1.4.3	4.7.1.2.3	EIA-455-173	2/
Mass/unit length	3.5.1.3	4.7.2.4		3/
Attenuation rate				
Multimode	3.6.2	4.7.2.2.1	EIA-455-46	3/
Singlemode	3.6.2	4.7.2.2.2	EIA-455-78	
Attenuation uniformity	3.6.2.1	4.7.2.2.3	EIA/TIA-455-59	3/
Numerical aperture 4/	3.6.3	4.7.3.3	EIA/TIA-455-177	2/
Bandwidth	3.6.4	4.7.3.4	EIA-455-51	3/
Macrobend attenuation	3.6.5	4.7.3.5	EIA-455-62	3/
Dispersion	3.6.6	4.7.3.6	EIA-455-175	3/
Cut-off wavelength 5/	3.6.7	4.7.3.7	EIA-455-80	2/
Transient attenuation	3.6.8	4.7.3.8	EIA-455-46	6/
Group II				
Tensile proof	3.5.2	4.7.2.2	EIA-455-31	4 @ 1100 m
Mechanical strippability	3.5.3	4.7.2.3	EIA/TIA-455-178	7/
Fluid immersion aging	3.7.5	4.8.5	EIA/TIA-455-75	8/
Dynamic tensile strength	3.7.10	4.8.10	EIA/TIA-455-28	9/
Group III				
Temperature cycling	3.7.3	4.8.3	MIL-STD-1678, method 4010	3 @ 1100 m
Storage temperature	3.7.11	4.8.11	MIL-STD-810 methods 501 & 502	10/
Thermal shock	3.7.1	4.8.1	MIL-STD-1678, method 4020	10/
Temperature humidity cycling	3.7.2	4.8.2	MIL-STD-1678, method 4030	10/
Nuclear radiation resistance 6/	3.7.6	4.8.6		11/
Fungus resistance	3.7.7	4.8.7	MIL-STD-810, method 508	12/
Life aging	3.7.4	4.8.4	MIL-STD-202, method 108	10/
Torsion	3.7.8	4.8.8	EIA-455-63	12/
Flexure	3.7.9	4.8.9	EIA-455-65	12/

See footnotes at end of table.

TABLE I. Qualification inspection. - continued

Inspection	Requirement paragraph	Test paragraph	Applicable test document	Specimen length
Group IV				
Thermal Vacuum outgassing	3.4.2.1	4.7.2.5.1	ASTM-E-595	13/
Odor	3.4.2.2	4.7.2.5.2	NHB-8060.1, TEST 6	13/
Toxicity	3.4.2.3	4.7.2.5.3	NHB-8060.1, TEST 7	13/

1/ The visual and mechanical inspection shall only be conducted on a 2 m section of the specimen.
2/ A specimen cut from each sample shall be used.
3/ The same specimen used in the visual and mechanical inspection shall be used.
4/ Multimode only.
5/ Single-mode only.
6/ One 1100 m specimen shall be used for this test.
7/ A specimen cut from each tensile proof sample.
8/ The same sample used in the tensile proof sample shall be used.
9/ Two 1100 m specimens from the fluid immersion aging test shall be used.
10/ The same sample used in the temperature cycling test shall be used.
11/ The fiber length shall be ≥200 m for residual gamma testing and ≥20 m for prompt gamma and neutron testing.
12/ A specimen cut from each temperature cycling sample.
13/ Finished material from a fiber sample.

4.6.2 Group A inspection. Group A inspection shall consist of the inspections and test specified in table II.

TABLE II. Group A inspection.

Inspection	Requirement paragraph	Test paragraph	Applicable test document
Group I			
Visual and mechanical inspection	3.4, 3.5, 3.7 3.8, 3.9,	4.7.2	EIA-455-13 EIA/TIA-455-60
Core diameter	3.5.1.3.4	4.7.1.1.4	EIA-455-58
Mode field diameter	3.5.1.3.2	4.7.1.1.2	EIA-455-167 or EIA-455-164
Core ovality	3.5.1.3.3	4.7.1.1.3	EIA/TIA-455-176
Cladding diameter	3.5.1.3.4	4.7.1.1.4	EIA/TIA-455-176
Cladding ovality	3.5.1.3.5	4.7.1.1.5	EIA/TIA-455-176
Core-to-cladding offset	3.5.1.3.6	4.7.1.1.6	EIA/TIA-455-176
Coating diameter	3.5.1.4.1	4.7.1.2.1	EIA-455-173
Overall coating concentricity ratio	3.5.1.4.3	4.7.1.2.3	EIA-455-173
Mass/unit length	3.5.1.3	4.7.2.4	
Attenuation rate 1/			
a. Multimode	3.6.2	4.7.2.2.1	EIA-455-46
b. Singlemode	3.6.2	4.7.2.2.2	EIA-455-78
Attenuation uniformity 1/	3.6.2.1	4.7.2.2.3	EIA/TIA-455-59

1/ These tests may be performed on the original reel from which a sample unit was cut.

4.6.2.1 Sampling plan. Group A inspection shall be performed on 100 percent of delivered product.

4.6.2.2 Disposition of sample units. Sample units from which a specimen has failed any of the group A inspection tests shall not be delivered on any order.

4.6.3 Group B inspection. Group B inspection shall consist of the inspections specified in table III. Group B inspections shall be made on units that have passed the Group A inspection.

4.6.3.1 Sampling plan. Sample units shall be selected from those types covered by a single specification sheet in accordance with table IV, except that the cladding diameter and cladding ovality shall be sampled at 100 percent, 3 months after the date of notification of qualification and every 3 months thereafter, except when the total production in a 3-month period is less than 2 units of product (2 Km) inspection need not be made until either production is at least 2 units of product or a total of 12 months has elapsed since the inspection was performed in which case only one sample unit shall be tested.

4.6.3.2 Failures. Production units in which one sample unit has failed a group B inspection test shall be rejected.

4.6.3.3 Rejected units. If a production unit is rejected, the supplier may screen out the defective units of product (if possible), and resubmit for reinspection. Resubmitted production units shall be inspected using tightened sampling (see 4.6.4.2). Such production units shall be separate from new production units, and shall be clearly identified as reinspected production units.

4.6.3.4 Disposition of sample units. Sample units from which a specimen has failed any of the group B inspections shall not be delivered on any order, even though the production unit submitted is accepted.

TABLE III. Group B inspection.

Inspection	Requirement paragraph	Test paragraph	Applicable test document
Mode field diameter	3.5.1.2.2	4.7.2.1.2	EIA-455-167 or EIA-455-164
Core diameter	3.5.1.2.1	4.7.2.1.1	EIA-455-58
Cladding diameter	3.5.1.2.4	4.7.2.1.4	EIA-455-176
Cladding ovality	3.5.1.2.5	4.7.2.1.5	EIA-455-176
Core ovality	3.5.1.2.3	4.7.2.1.3	EIA-455-176
Core-to-cladding offset	3.5.1.2.6	4.7.2.1.6	EIA-455-176
Coating diameter	3.5.1.2.7	4.7.2.1.7	EIA-455-173
Overall coating concentricity ratio	3.5.1.2.8	4.7.2.1.8	EIA-455-173
Numerical aperture	3.6.3	4.7.3.3	EIA/TIA-455-177
Bandwidth	3.6.4	4.7.3.4	EIA-455-51
Dispersion	3.6.6	4.7.3.6	EIA-455-175
Cut-off wavelength	3.6.7	4.7.2.7	EIA-455-80
Tensile proof	3.5.2	4.7.2.2	EIA-455-31
Mechanical strippability	3.5.3	4.7.2.3	EIA/TIA-455-178

TABLE V. Sampling plan for group B inspection.

Units of product from 3-months production	Sample unit size
2	1
3 to 8, inclusive	2
9 to 30, inclusive	3
31 to 80, inclusive	4
81 to 130, inclusive	5
131 to 180, inclusive	6
181 to 240, inclusive	7
241 to 300, inclusive	8
over 300	4 percent

4.6.4 Group C inspection. Group C inspection shall consist of the inspections specified in table IV. Group C inspection shall be made on sample units selected from production lots which have passed the groups A and B inspection.

4.6.4.1 Sampling plan. Sample units shall be selected from those types covered by a single specification sheet in accordance with table V. Group C shall be conducted 36 months after the date of notification of qualification, and every 36 months thereafter, except when the total production in a 36-month period is less than 11 units of product; inspection need not be made until production is at least 11 units of product.

4.6.4.2 Failures. If one or more sample units fail to pass group C inspection, the production unit shall be considered to have failed.

4.6.4.3 Disposition of sample units. Sample units which have been subjected to group C inspection shall not be delivered on the contract.

4.6.4.4 Noncompliance. If a sample fails to pass group C inspection, the supplier shall notify the qualifying activity and the cognizant inspection activity and take corrective action on the materials or processes, or both, as warranted. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance shall be withheld until the group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

TABLE IV. Group C inspection.

Inspection	Requirement paragraph	Test paragraph	Applicable test document
Subgroup 1			
Macrobend attenuation			EIA-455-62
Temperature cycling	3.7.4	4.8.4	MIL-STD-1678, method 4010
Storage temperature			MIL-STD-810, methods 501 & 502
Subgroup 2			
Thermal shock	3.7.1	4.8.1	MIL-STD-1678, method 4020
Temperature humidity cycling	3.7.3	4.8.3	MIL-STD-1678, method 4030

TABLE IV. Group C inspection. - continued

Inspection	Requirement paragraph	Test paragraph	Applicable test document
Subgroup 3			
Nuclear radiation 1/ resistance	3.7.7	4.8.7	
Life aging	3.7.5	4.8.5	MIL-STD-202, method 108
Torsion			EIA-455-63
Flexure			EIA-455-65
Subgroup 4			
Fluid immersion aging			EIA/TIA-455-75
Dynamic tensile strength			EIA/TIA-455-28
Dynamic fatigue in tension			EIA/TIA-455-76
Thermal Vacuum outgassing	3.4.2.1		ASTM-E-595
Odor	3.4.2.2		NHB-8060.1, test 6
Toxicity	3.4.2.3		NHB-8060.1, test 7

See footnotes on next page.
1/ Only residual gamma radiation tests at the temperature of maximum change in optical transmittance during qualification testing are required.
2/ These tests may be waived by the qualifying activity

TABLE V. Sampling plan for group C inspection.

Units of product from 12-months production	Sample unit size
11 to 200, inclusive	2 percent of sample
201 to 500, inclusive	2 percent of sample
501 to 1000, inclusive	2 percent of sample
1001 to 1500, inclusive	2 percent of sample
over 1500	1 percent of sample

4.6.5 Inspection of packaging. The sampling and inspection of the preservation, packing and container marking shall be in accordance with the requirements of 3

4.7 Methods of inspection.

4.7.1 Equivalent test methods. The use of equivalent test methods is allowed subject to the following conditions:

a. the allowance of an equivalent method is specified in this specification.
b. the manufacturer has conducted both test methods during qualification and has submitted complete test data to the Preparing Activity (PA).
c. the PA has approved the use of that method by that manufacturer.

4.7.2 Visual and mechanical inspection. The optical fiber shall be inspected in accordance with EIA-455-13 to verify that the design, construction, physical characteristics and dimensions, marking, and workmanship are in accordance with the requirements of 3.4, 3.5, 3.6, 3.7, and 3.8. Fiber length shall be measured in accordance with EIA/TIA-455-60.

4.7.2.1 Fiber geometry. Fiber geometry shall be determined as specified below.

4.7.2.1.1 Core diameter (multimode fiber only). Core diameter shall be determined in accordance with EIA-455-58 (see 3.5.1.2.1).

4.7.2.1.2 Mode field diameter (singlemode fiber only). Mode field diameter shall be determined in accordance with EIA-455-167 or EIA-455-164 (see 3.5.1.2.2). In the case of a dispute between the two test methods, EIA-455-167 shall be used.

4.7.2.1.3 Core ovality (multimode fiber only). Core ovality shall be determined in accordance with EIA-455-176 (see 3.5.1.2.3).

4.7.2.1.4 Cladding diameter. Cladding diameter shall be determined in accordance with EIA-455-176 (see 3.5.1.2.4).

4.7.2.1.5 Cladding ovality. Cladding ovality shall be determined in accordance with EIA-455-176 (see 3.5.1.2.5).

4.7.2.1.6 Core-to-cladding offset. Core-to-cladding offset shall be determined in accordance with EIA-455-176 (see 3.5.1.2.6).

4.7.2.1.7 Coating diameter. Coating diameter shall be determined in accordance with EIA-455-173 (see 3.5.1.2.7).

4.7.2.1.8 Overall coating concentricity ratio (OCCR). The overall coating concentricity ratio shall be determined in accordance with EIA-455-173 (see 3.5.1.2.7).

4.7.2.2 Tensile proof. Fiber proof test characteristics shall be determined in accordance with EIA-455-31 (see 3.5.2).

4.7.2.3 Mechanical strippability. The strip force of each individual fiber shall be measured in accordance with EIA/TIA-455-178. Fibers shall be stripped of their coatings with the use of a commercially available mechanical fiber stripper. After stripping, the fiber shall be inspected under 10X magnification for compliance (see 3.5.3).

4.7.2.4 Fiber mass/unit length (see 3.5.1.3). The fiber shall be measured using scales with an accuracy of ±5 percent to verify conformance to the requirements.

4.7.2.5 Materials tests for space applications.

4.7.2.5.1 Thermal Vacuum Outgassing. Non-metallic materials shall meet the requirements of 3.4.2.1 when tested in accordance with ASTM-E-595.

4.7.2.5.2 Odor. Material samples shall meet the requirements of 3.4.2.2 when tested in accordance with NASA Handbook 8060.1, Test 6.

4.7.2.5.3 Toxicity. Material samples shall meet the requirements of 3.4.2.3 when tested in accordance with NASA Handbook 8060.1, test 7.

4.7.3 Optical inspections.

4.7.3.1 Change in optical transmittance. This test shall evaluate the change of attenuation of the fibers due to exposure to one or more inspection (environmental and physical) tests (see 3.6.1). The wavelength tested shall be as specified in the applicable specification sheet (see 3.1). The periodicity of the measurement shall be appropriate for the test method and as approved by the qualifying activity.

4.7.3.1.1 Method. The change in optical transmittance of each fiber shall be measured in accordance with RS-455-20, utilizing a monitor fiber taken from the same sample under test, to evaluate the change in attenuation due to exposure to environmental and physical tests. Light launch conditions for multimode fiber shall be as specified in EIA-455-50. For multimode fibers, the source used shall be non coherent. Any optical power detection method may be utilized if the method is sufficiently sensitive to measure the differential optical power levels as specified (see 3.6.1), and if the method provides repeatable readings (less than 3 percent variation). A pretest optical power measurement shall be made and the specimen shall then undergo inspection testing. All optical power measurements, subsequent to the pretest measurement, shall be referenced to the pretest value and the change in dB calculated.

4.7.3.2 Attenuation rate (see 3.6.2).

4.7.3.2.1 Attenuation rate (for multimode fibers only). The attenuation rate of each individual fiber shall be measured in accordance with EIA-455-46. Light launch conditions utilized during the attenuation rate measurements shall be in accordance with EIA-455-50, procedure B or equivalent (see 3.6.2).

4.7.3.2.2 Attenuation rate (for singlemode fibers only). The attenuation rate of each individual fiber shall be determined in accordance with EIA/TIA-455-78.

4.7.3.2.3 Attenuation uniformity. The attenuation uniformity of each individual fiber shall be measured in accordance with EIA-455-59. The uniformity shall be measured from both ends of the fiber, and shall meet the requirements specified in 3.6.2.1.

4.7.3.3 Numerical aperture. The numerical aperture shall be determined in accordance with EIA-455-177 (see 3.6.3).

4.7.3.4 Bandwidth. The multimode fiber bandwidth shall be determined in accordance with EIA-455-51 or equivalent using the light launch conditions of EIA-455-54. The bandwidth shall meet the requirement specified in 3.1 and 3.6.4.

4.7.3.5 Macrobend attenuation. The macrobend attenuation of each individual fiber shall be measured in accordance with EIA-455-62. Launch conditions shall be in accordance with 4.7.3.1.1. Macrobend attenuation shall meet the requirements specified in 3.6.5.

4.7.3.6 Chromatic Dispersion. The chromatic dispersion characteristics for single-mode fibers shall be determined in accordance with EIA-455-175 or equivalent (see 3.6.6).

4.7.3.7 Cutoff wavelength. The cutoff wavelength of singlemode fibers shall be determined in accordance with EIA-455-80 (see 3.6.7).

4.7.3.8 Transient attenuation. The transient attenuation shall be measured as follows. The attenuation shall be measured in accordance with EIA-455-46 using overfilled launch conditions without mode filter or cladding mode strippers. Then the attenuation of the sample shall be measured in accordance with EIA-455-46, procedure B. The transient attenuation is defined as the difference in the two attenuation values obtained.

4.8 Environmental inspections.

4.8.1 Thermal shock. The characteristics of the optical fiber when exposed to temperature shock shall be determined in accordance with MIL-STD-202, method 107. Test condition A shall be utilized. Temperatures shall be -62C (+0C, -3C) and +85C (+3C, -0C) (see 3.7.1). The change in optical transmittance shall be measured after the test.

4.8.2 Temperature humidity cycling. The fibers shall be tested in accordance with MIL-STD-1678 method 4030 (see 3.7.2). The change in optical transmittance shall be measured during and after the test.

4.8.3 Temperature cycling. The fibers shall be tested in accordance with the following conditions and cycle (see 3.7.3):

Step		Temperature (C)	Duration (hours)
1.		Room ambient	24
2.	Reduce to	-54C to +0C, -3C	2
3.	Hold		8
4.	Increase to	+25C ±2C	2
5.	Hold		6
6.	Increase to	+85C +3C, -0C	1
7.	Hold		6
8.	Reduce to	+25C ±2C	1
9.	Hold		6
10.	Repeat steps 2 through 9 four additional times for a total of five cycles.		

Change in optical transmittance shall be measured during and after the test.

4.8.4 Life aging. The fibers shall be tested in accordance with MIL-STD-202, method 108. Temperature shall be +95C +3C, -0C. The time shall be 500 hours. The frequency of change in optical transmittance measurements shall be daily (see 3.7.4).

4.8.5 Fluid immersion aging. The fiber shall be immersed in the specified fluids(s) for the duration and temperature as specified (see 3.1) in accordance with EIA-455-75. The samples shall be dried or drained as recommended in the test procedure. After a minimum 24 hour period, the samples shall be tested in accordance with EIA-455-28 (see 3.7.5).

4.8.6 Nuclear radiation resistance. The fibers shall be tested as specified in the appendix to this specification for gamma radiation, prompt gamma radiation, and neutron radiation (see 3.7.6). Optical characteristics shall be verified at the low operating temperature and at 25C. The change in optical transmittance shall be measured during and after the test. If the change in optical transmittance at 25C is greater than the change in optical transmittance at the low operating temperature, the fiber shall be tested at the high operating temperature.

4.8.7 Fungus. The fibers shall be tested in accordance with MIL-STD-810, method 508 (see 3.7.7).

4.8.8 Torsion. The fiber shall be tested in accordance with EIA-455-63. The test length shall be 10 meters and the twist angle shall not exceed 15 degrees. The tensile load shall be 350 MPa, and the total torque shall be 25 N·cm. The change in optical transmittance shall be measured during and after this test.

4.8.9 Flexure. The fiber shall be tested in accordance with EIA-455-65. The test length shall be 10 meters and the test temperature shall be the low operating temperature. The test shall consist of 25 cycles of 5 turns about a 30 mm diameter mandrel. The change in optical transmittance shall be measured during and after this test.

4.8.10 Dynamic tensile strength. Fifteen fiber specimens shall be preconditioned in 100 percent relative humidity for an minimum of 12 hours. The specimens shall then be tested in a 100 percent RH environment in accordance with EIA-455-28. The mean fracture strength and Weibull modulus shall be calculated (see 3.7.10).

4.8.11 Dynamic fatigue in tension. The fiber specimens shall be preconditioned in 100 percent RH for a minimum of 12 hours. The specimens shall then be tested in a 100 percent RH environment in accordance with EIA-455-176. The stress corrosion parameter, n, shall be calculated (see 3.7.11).

4.8.12 Storage temperature. The fibers shall be tested in accordance with MIL-STD-810, method 501, procedure I and method 502, procedure I (see 3.7.12). Test duration shall be 240 hours. The change in optical transmittance shall be measured after the test.

5. PACKAGING

5.1 Packaging requirements. Unless otherwise specified in the contract (see 6.2) and except as specified herein, the requirements for the packaging of optical fiber shall be in accordance with standard commercial practices.

5.2 Reels and spools. The optical fiber of each reel or spool shall have at least 1 meter of each end readily available for testing. The inner end shall be available at the outer surface of the reeled optical fiber. Both ends of the optical fiber shall be secured to a flange.

5.3 Marking of reels and spools. In addition to the marking specified in MIL-STD-129, each reel or spool shall be marked with the manufacturer's part number, Federal Supply Code for Manufacturers, the length of fiber and the specification sheet number.

6. NOTES
(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory)

6.1 Intended use. The optical fibers covered by this specification are intended for use in any application where their performance characteristics are required. The fibers are suitable for installation on aerospace systems within the limitations of applicable performance requirements.

6.1.1 Temperature rating. Temperature ratings as specified in specification sheets pertaining to this specification represent the maximum permissible operating temperature range of the fiber.

6.1.2 Materials compatibility. The coating of the fibers covered by this specification may be degraded by certain fluids or compounds. If such degradation occurs, the fluids or compounds and the conditions necessary for failure shall be added to the specification sheet as a precautionary note.

6.2 Ordering data. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Applicable specification sheet number, title, and date.

c. Applicable specification sheet part number.

d. Quantity of fiber required.

e. Level of packaging and packing required.

f. Color coded coating of the optical fiber, if specified (see 3.8).

g. Equivalent test methods as approved by the qualifying activity, if other than as specified (see 4.7).

h. Exceptions, if any to the optional provisions of this specification including:

(1) Exceptions to identification of product requirements (3.6) if applicable.
(2) Applicable minimum length requirements, if other than specified.
(3) Responsibility for inspection, if other than specified in 4.1.
(4) Special preparation for delivery requirements, if applicable (section 5).

i. Any data requirements.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for such products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 49291 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the US Army Communications-Electronics Command. The Defense Electronics Supply Center, DESC-EQ, Dayton, OH 45444, has been designated by the US Army Communications-Electronics Command as agent for the establishment of the QPL. Requests for information pertaining to and applications for qualification should be addressed to: Defense Electronics Supply Center, DESC-EQ, Dayton, OH 45444.

6.3.1 Conformity to qualified sample. It is understood that fiber supplied under contract shall be identical in every respect to the qualification sample tested and found satisfactory, except for changes previously approved by the Government. Any unapproved changes from the qualification sample shall constitute cause for rejection.

6.3.2 Extent of qualification. In instances where two or more specification sheets cover fibers identical in materials and construction except for attenuation, the fiber with the lowest attenuation range shall be submitted and shall meet all the requirements of this specification and the specification sheet (see 3.1). Qualification may be extended to include those fibers with higher attenuation provided the samples submitted in accordance with 4.5.1 meet the attenuation and fiber size specified in the specification sheet.

6.3.3 Forwarding of qualification samples. Samples and the manufacturer's certified test reports shall be forwarded to the testing laboratory designated in the letter of authorization from the activity responsible for qualification (see 6.3), plainly identified by securely attached, durable tags marked with the following information:

Sample for qualification test.

Fiber, Optical, GENERAL SPECIFICATION FOR.

Specification sheet part number.

Manufacturer's name and code number.

Manufacturer's part number

Comprehensive description and prime manufacturer's name and formulation number of the base materials from which the product is made. This information will not be divulged by the Government.

Place and date of manufacture of sample.

Submitted by (name) (date) for qualification tests in accordance with the requirements of this specification under authorization (reference authorizing letter).

6.3.4 Application for qualification.

6.4 Definitions. Definitions of terms shall be in accordance with EIA-440 and the following:

6.4.1 Cladding ovality. The cladding ovality is the measure of the degree of roundness of the cladding. It is expressed as the difference between the largest cladding diameter and the cladding diameter measured at right angles to it, all divided by the average of the two values.

6.4.2 Core/cladding offset. The core/cladding offset is the distance between the central axis of the core and the central axis of the cladding.

6.4.3 Core ovality. The core ovality is the measure of roundness of the core. It is expresses as the difference between the largest core diameter and the core diameter measured at right angles to it, all divided by the average of the two values.

6.4.4 Fiber/coating offset ratio. Fiber (core/cladding) to coating offset ratio is determined by measuring the minimum wall thickness (min.) and the maximum wall thickness (max) and dividing the minimum by the maximum value (see figure 1).

6.4.5 Transient attenuation. Transient attenuation, in multimode fiber, is the increase (or decrease) in attenuation from the steady-state attenuation because of the over (or under) excitation of the lossy high order propagating modes compared with the steady-state distribution. The steady-state distribution is the condition in which the relative power distribution among the propagating modes is independent of longitudinal distance.

6.5 Part or Identifying Number (PIN). The PIN shall be constructed in accordance with the following:

M49291/ X - XXX

Optical fiber basic specification

Optical fiber specification sheet

Serial number

Examples:
M49291/1-001
M49291/2-001

6.6 Subject term (key word) listing.

Aperture, numerical
Attenuation, optical
Bandwidth, fiber
Coating material
Coating, fiber
Cladding
Core
Diameter, cladding
Diameter, core
Distortion, pulse
Fiber, optical
Fiber optics
Fiber, plastic clad silica
Graded index profile
Inclusion
Microbending
Microbend loss
Profile, index
Profile, refractive index
Refraction, index of
Volume, mode

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

APPENDIX

PROCEDURE TO MEASURE NUCLEAR RADIATION
EFFECTS IN FIBER OPTIC COMPONENTS

10. SCOPE

10.1 Scope. This procedure describes a method for the determination of transient and steady-state nuclear radiation effects in optical fibers, cables or devices. It should be noted that either or both of the measurements can be performed depending on the data that is desired. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. TEST EQUIPMENT

30.1 Test equipment. The following test equipment shall be used as required for testing in the configuration as shown. Optical, mechanical and thermal stability of the test setup is necessary to facilitate movement of the test setup enabling the test sample to be subjected to environmental tests following the coupling loss test.

30.1.1 Radiation source. Three types of sources depending on the type of measurement being performed are as follows.

30.1.1.1 Transient radiation pulse response. A source shall produce at least 450 rads (Si) total dose with a pulse width of 1 us or less. (A bremsstrahling x-ray beam may be obtained by placing a tantalum target in front of the electron beam.) An example of the test equipment is shown on figure 1.

30.1.1.2 Steady-state response. The container is placed in a Cobalt-60 source to deliver gamma rays at doses from 3000 $\pm$ 100 rads (Si) minimum to 18,000 $\pm$ 100 rads (Si) maximum. An example of test equipment is shown on figure 1.

30.1.1.3 Neutron fluence measurements. The container is placed in a reactor which delivers a density of fast neutrons (<1 MeV) at a nominal fluence of 10^{12}n/cm^2-second. An example of the test equipment is shown on figure 2.

30.1.2 Light source. A light source shall be sued with an output power of about 100 uW but not more than 1mW for multimode fiber. Note: If a source of more than 100 uW is used, photo-bleaching phenomenon may occur. Lower power levels may be usable depending on the dynamic range of the overall system. For single mode fiber the power may have to be increased to get adequate light coupled into the fiber. Wavelengths of 850 +- 10nm and 1300 +- 10nm shall be used unless otherwise specified.

30.1.3 Input optics. A system of optical components shall be used to create a monochromatic (less than or equal to 10 nm full width half maximum (FWHM)), substantially constant radiance spot larger in diameter than that of the specimen, unless otherwise specified by another fiber optic test procedure. A means of verifying the alignment of the endface shall be provided, such as a mounted telescope tube. Optical filters may be used to limit the spectral bandwidth of the source. For multimode fibers, an equilibrium mode simulator shall be utilized (see 30.1.7).

30.1.4 Specimen support and alignment. A means of supporting the input end of the specimen shall be arranged to allow stable and repeatable positioning without introducing significant deformation. Suitable means shall be provided to align the input endface with respect to the launch radiation.

30.1.5 Cladding mode stripper. Cladding mode stripper is a device which extracts only cladding modes and is used reasonably near the ends of the fiber under test. In an effort to completely characterize the fiber, two measurements will be performed for each test: One measurement without any cladding mode strippers and one with cladding mode strippers on each end of the test fiber. It is felt for short lengths of fiber there will be cladding mode propagation in actual system use hence, no mode strippers are used. If an index-matching fluid which is hygroscopic (such as glycerin) is used, it shall be replenished frequently. If the fiber is to be held against a flat, horizontal surface containing the index-matching fluid, small weights may be used to held it in intimate contact.

30.1.6 Detector, signal detection electronics. A detector which is linear within 5 percent over the range of detected intensities shall be used. A typical system may include a PIN photodiode, with a rise/fall time of 1 ns or lower; an oscilloscope with a bandwidth of 200 MHz for the transient response measurement, and a chart recorder for the steady-state measurement.

30.1.7 Equilibrium modal simulator (EMS). An EMS is used to attenuate higher order modes and to arrive at a steady-state condition, only for multimode, graded-index fiber. There are a number of methods to accomplish this: A mandrel-wrapped mode filter or a restricted launch condition created by beam optics are examples. Refer to FOTP-50 (RS-455-50), "Light Launch Conditions for Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements" for directions on how to measure for the light launch conditions. In an effort to completely characterize the fiber, an EMS will be used with the cladding mode strippers and not used during the measurement done without cladding mode strippers.

30.1.8 Beam splitter. A beam splitter or fiber optic coupler shall be used to couple the light beam into the specimen fiber and provide a reference signal. The splitter or coupler shall divert a small portion of the input light to a reference detector. The reference path shall be such that the system fluctuations can be monitored during the entire time that measurements are taken (see figure 1).

30.1.9 Fiber support. A means of stable support for the input end of the fiber shall be arranged (for example, a vacuum chuck can be used). The total length of the fiber shall be handled such that microbending attenuation is kept to a minimum.

30.1.10 Radiation dosimeter. The detection system will be dependent on the type of radiation source used.

30.1.10.1 Transient radiation pulse. A Faraday Cup and a plastic scintillator detector shall be used to determine the transient radiation shape. A 200 MHz bandwidth oscilloscope shall be part of the scintillator detection system. Thermoluminescent LiFs or CaFs Crystal Detectors (TLDs) shall be used to measure the total dose received by the specimen fiber.

30.1.10.2 Long duration radiation. TLDs shall be used to measure the total dose received by the specimen fiber.

30.1.11 Collimator. By placing the fiber behind the collimator, the radiation beam will be collimated with respect to the fiber. This will limit the length of fiber subject to radiation.

30.1.12 Interference filter. A 10nm bandwidth interference filter shall be placed between the output of the fiber and detector. The filter shall have a center wavelength that matches the optical source.

30.1.13 Temperature controlled container. The temperature controlled container shall have the capability of temperatures from -55°C to +125°C. The chamber shall be remotely controlled or programmable to allow change of chamber temperature. The chamber shall be capable of a rate of change of 2°C minimum. The chamber shall be able to maintain a temperature 10 ± 1°C.

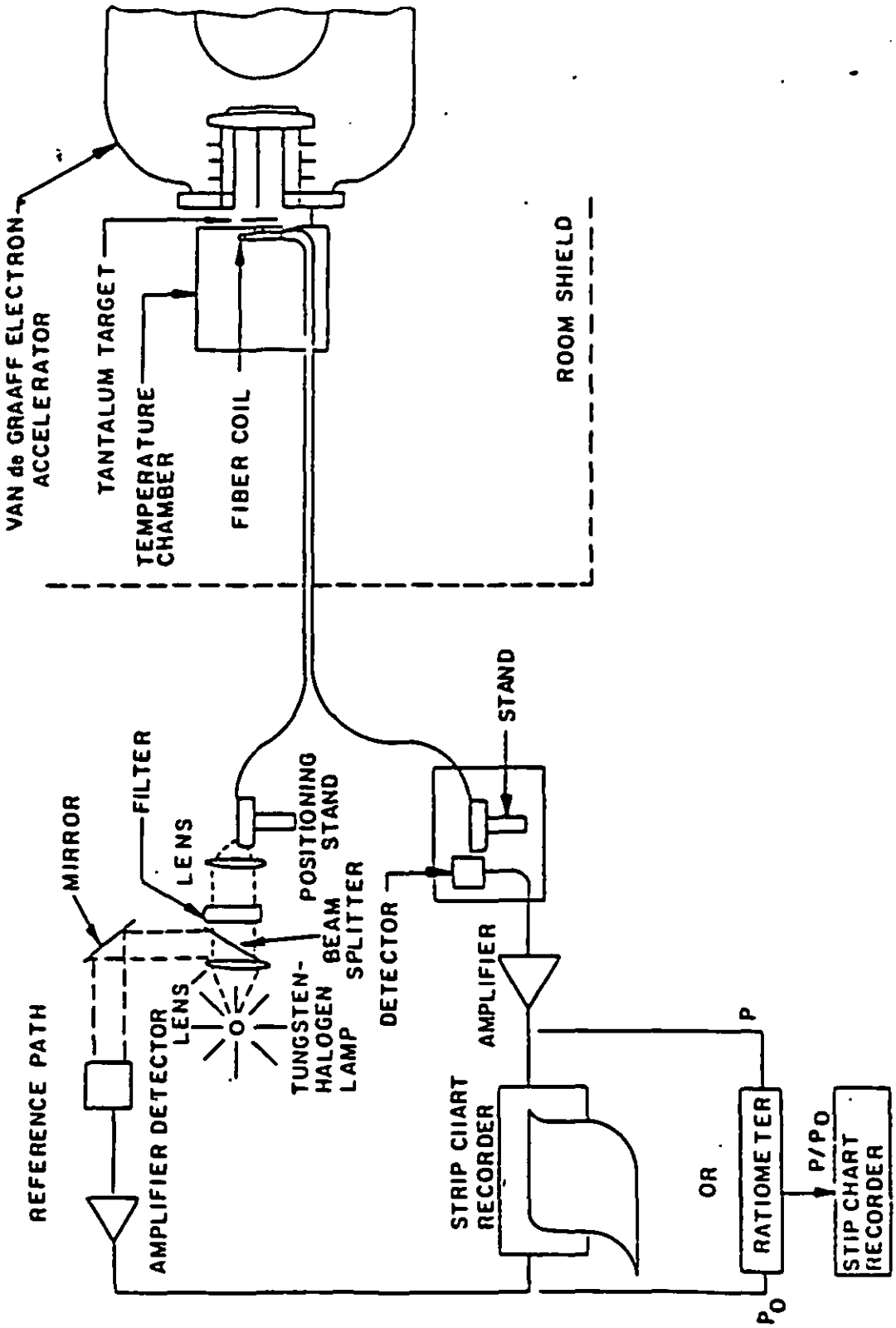

FIGURE 1. Prompt gamma radiation test instrumentation example.

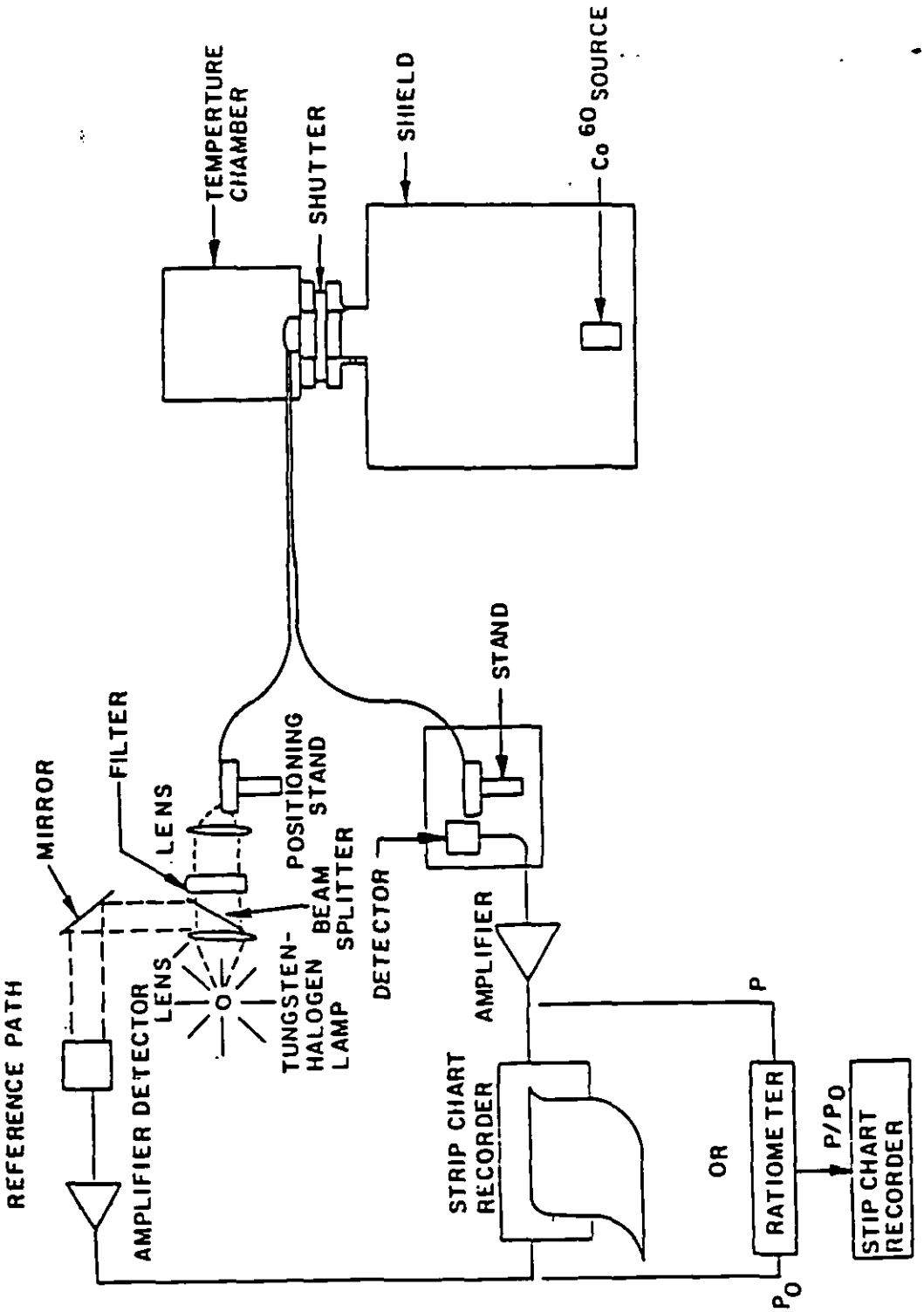

FIGURE 2. Total gamma radiation test instrumentation example.

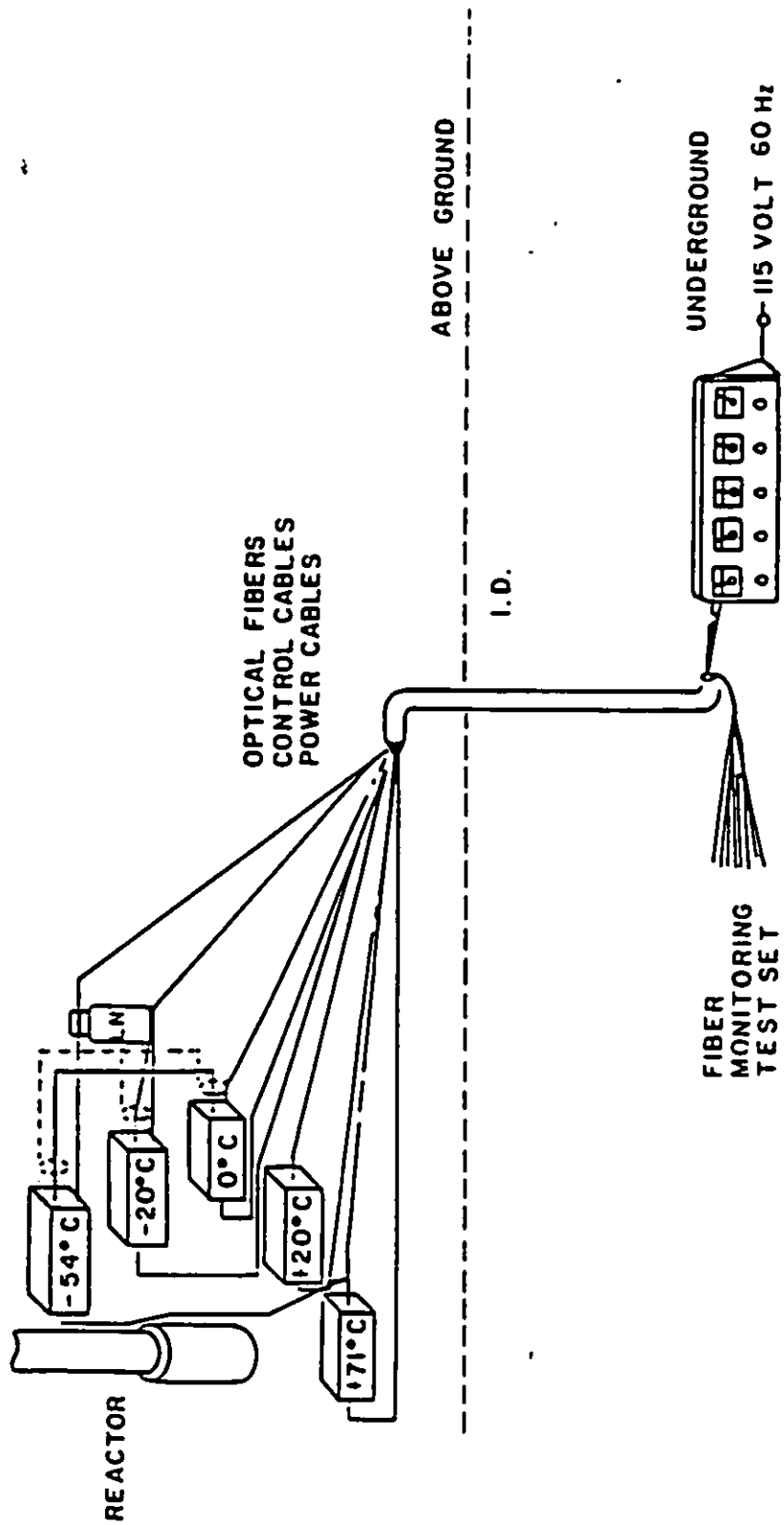

FIGURE 3. Neutron fluence radiation test apparatus example.

APPENDIX

40. TEST SAMPLE

40.1 Specimen. The specimen to be measured shall be a component such as an interconnecting device or a length of representative fiber or cable. The minimum length of the specimen outside the chamber shall be that which is required to install the fiber from the source to the detector, unless otherwise specified (see 3.1). The maximum length shall be ten times the exposed length or 1 km, whichever is shorter, unless otherwise specified (see 3.1).

40.2 Reference path. The reference path shall be through the beam splitter and associated optics (see figures 1, 2, or 3).

40.3 Measured test length. The length of the test fiber shall be recorded in the results, if different from the 1 km length specified above.

40.4 Sample configuration. Unless otherwise specified, the specimen for the steady-state evaluation shall be spooled on a reel with a 4- to 12-inch drum diameter, which will depend upon the sample length. Allowance shall be made for the unspooling of a measured length of fiber from each end of the reel to allow for attachment to the optical power measurement equipment.

40.5 Exposed length. The length of the exposed section of specimen will vary for the test setup used, the nature of the specimen, etc. For a particular measurement system, for example, the experimenter may find that up to 250 m of exposed specimen, may be necessary to obtain an accurate loss measurement. In any event, the length of specimen exposed shall be noted in the test report.

40.5.1 Exposed length (minimum) (see 3.1). Unless otherwise specified, the recommended minimum exposure lengths given below shall be sued for measurement at noted:

Measurement	Specimen type	Exposure section length
Transient	Glass-on-glass	50 +- 5 m
	Plastic or plastic-clad silica	50 +- 5 m
Steady-state	Glass-on-glass	50 +- 5 m
	Plastic or plastic-clad silica	50 +- 5 m

50. TEST PROCEDURE

50.1 High dose calibration. If the specimen is to be tested at a high dose-rate, calibration of the radiation source shall be done before the specimen is set up in the system. Four TLDs shall be placed in the area of exposure and the center of the TLDs shall be placed where the axis of the specimen will be placed (Four are used to get a representative average value.) A dose equal to than the actual test dose shall be sued to calibrate the system.

50.2 Calibration accuracy. To maintain the highest possible accuracy in measuring the test dose, the TLDs shall not be used more than more.

50.3 Transient radiation pulse calibration. If a transient radiation pulse is to be used, the pulse width and shape shall be calibrated to obtain the required radiation exposure.

50.4 Numerical aperture (NA). Determine the far-field NA of the specimen under test by the method of FOTP-47, "Output Far-Field Radiation Pattern Measurements." This is done so that the input optics can be adjusted to obtain an overfilled NA and core conditions.

50.5 System exposure effects on calibration. Before the specimen is put into the radiation exposure system, but while the specimen is connected to the optical measurement system, the radiation source shall be run to determine its effect on the system. If the measurement is affected by operation of the radiation source, the measurement system shall be shielded against the interference and recalibrated to assure the proper operation.
Note: The measurement system should be outside the radiation chamber.

50.6 Specimen preparation. If the input to the specimen or the specimen itself is a fiber, then the fiber shall be prepared so that the endfaces are smooth and perpendicular to the fiber axis, in accordance with FOTP-57, "Fiber End and Fiber Bundle Terminum Preparation".

50.7 Specimen mounting facilities. The specimen shall be placed in the test setup (see figure 1, 2, or 3) such that the test section shall be exposed to the beam.

50.7.1 Fiber alignment. For fiber input, the input end of the fibers shall be placed in a positioning device and aligned. The output end shall be positioned so that all light exiting the fiber impinges on the detector.

50.8 Sample precondition. The sample shall be preconditioned for 2 hours prior to testing at the test temperature.

50.9 Coupled power. The coupled power shall be determined at the test wavelengths by adding the power loss of the fiber or fiber optic device, or both, to the absolute power at the detector-end of the long length.

50.9.1 Attenuation measurement. Perform an attenuation measurement on the test sample in accordance with the methods of FOTP-46 (RS-455-46), "Special Attenuation Measurement" for long-length, graded-index optical fibers. For graded index fibers, or in accordance with FOTP-20 (RS-455-20), "Measurement of Change in Optical Transmittance" for other fibers. Record the attenuation, A_b of the sample.

50.9.2 System restoration. Restore the system as outlined in 50.7.1 to get ready for the actual measurement.

50.10 System alignment, radiation source off. The input end of the specimen under test shall be positioned so maximum optical power is received at the detector. Once set, the input launch conditions should not be changed during the balance of the test.

50.11 Preirradiation power measurement. Prior to irradiation, measure the output power at all test wavelengths at the test temperature that will be used.

50.12 Irradiation exposure. Once the system has been aligned, the irradiation sequence may begin (either step 50.13, 50.14, or 50.15).

50.13 Transient radiation pulse measurements. The test transient radiation effects is determined by subjecting test specimen to at least 450 rads (Si) total dose in a time period of 1 us or less. During the radiation pulse, the detector may be inoperative to eliminate the effects of the luminescence caused by the radiation. Begin optical power measurements 100 ns after the radiation pulse is terminated. The measurement schedule thereafter shall be as follows:

Time after radiation terminated		Measurement frequency
From	To	Every
100 ns	1 us	100 ns
1 us	10 us	1 us
10 us	100 us	10 us
100 us	10 ms	100 us
10 ms	1 s	10 ms
1 s	10 s	100 ms
10 s	10 minutes	10 s
10 minutes	30 minutes	30 s

50.14 Steady-state measurements. Steady-state nuclear effects shall be determined by subjecting the test specimen to dose rates of 50 rads (Si) second with a total dose of up to 10,000 rads (Si). A $60^{o}C$ source or equivalent shall be used to provide the radiation. During the radiation exposure, the power out measurement is recorded continuously. A chart recorder shall be connected to the detection system so that a continuous power measurement is made. The chart recorder shall be set up such that the detection signal does not exceed the limits of the recorder.

50.15 Neutron fluence measurements. Neutron fluence effects shall be determined by subjecting the test specimen to a neutron exposure at a nominal fluence of 10^{12} N/cm^2 in a pulse of approximately 1 ms. During the neutron pulse, the detector may be inoperative to eliminate the effects of the luminescence caused by the radiation.

50.16 Relative detected power measurement. For transient and neutron testing, measurements shall continue until the output power is within 5 percent of the preirradiated level or to the point where the output power value for three consecutive measurements. For the steady-state testing, measurements shall continue until the output power is within 5 percent of the preirradiated level or to the point where there is no perceivable change in output power. Repeat steps 50.6 through 50.12 for the required test temperatures. It will be necessary to use a new nonirradiated specimen for each temperature required.

50.17 Radiation hardening. If radiation hardening is required by the specification sheet (See 3.1), the following operational sequence shall be followed:

a. Steps 50.1 through 50.12 shall be performed.

b. The specimen shall be subjected to radiation two orders of magnitude greater than the level at which the specimens will be tested.

c. The specimen shall be tested after the output power has decreased to within 5 percent of the preirradiated level or to the point where there is no perceivable change in output power.

d. Steps 50.12 through 50.17 shall be performed to determine the radiation hardening characteristics of the specimen.

60. CALCULATIONS

60.1 Far-field numerical aperture calculations. See FOTP-47.

60.2 Coupled power into fiber. To find the coupled power into the specimen from the source, the following formula is used:

$$P_c = (P_o) \ / \ 10(A_b/10)$$

where P_b = Power output from long length.

A_b = Attenuation of specimen, as determined 50.9.1.

60.3 Change in optical transmittance calculations. The change in Optical Transmittance (A) shall be calculated for each wavelength by using the following formula:

$$A \text{ (in dB)} = -10 \log 10 \ (P_a/P_B)$$

where P_A is the measured output of the specimen fiber after irradiation

P_B is the measured output of the specimen fiber before irradiation

In case of the radiation hardening section, P_B is the measurement before the last irradiation.

60.4 Normalized change in optical transmittance calculations. The results of the reference signal shall be used to normalize the test results.

$$A_{ref} \text{ (in dB)} = -10 \log 10 \ (P_A1/P_B1)$$

where P_A1 is the power at the reference detector at the end of the measurement.

The test results that are normalized for system fluctuations are found by use of the following formula:

Anor (in dB) = A - A_{ref}

where A_{nor} is the output power of the specimen fiber when normalized against system fluctuations.

70. DOCUMENTATION

70.1 Test report. The following information shall be reported:

a. Operator.

b. Date.

c. Identification of specimen. Fiber characteristics such as fiber composition, fiber dimensions and delta index change shall be reported.

d. Optical source type, wavelength and spectral width.

e. Optical source characteristics, i.e., spot size and beam numerical aperture.

f. Method of stripping cladding modes.

g. Length of specimen of fiber.

h. Length or area of specimen exposed to the radiation.

i. For Transient Pulse Measurement, the behavior of the detector to a 300 picosecond rise time pulse at 850 and 1300 nm shall be documented.

j. The specimen's and reference's output power with respect to time shall be recorded.

k. Characteristics of the interference filters.

l. The calculated input coupled power into the test fiber shall be recorded.

80. SUMMARY

80.1 Required test condition. The following shall be specified in the detail specification:

a. Type of specimen material to be tested.

b. Procedure number to be referenced (FOTP).

c. Test conditions.

(1) Temperature.

(2) Length of specimen section exposed.

(3) Type of radiation.

(4) Exposure rate and duration.

(5) Type of dosimeters used.

(6) Type of measurement (transient or steady-state).

(7) Whether radiation hardening is to be tested.

d. Acceptance criteria.

(1) Specimen response characteristics.

(2) Recovery time of specimen.

(3) Allowable permanent damage.

Custodians:
Army - CR
Navy - EC
Air Force - 85
NASA - NA

Review activities:
Army - AR, MI, SC
Navy - EC, OS
Air Force - 11, 13, 99
DLA - ES

User activity:
Army - AV

Preparing activity:
Army -CR

Agent:

DLA -ES

(Project 6010-0036)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-F-49291B	92/07/08

3. DOCUMENT TITLE
Fiber, Optical, (Metric) General Specification For

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial	(2) AUTOVON
U.S. Army Communications-Electronics Command	908-532-5851	992-5851
c. ADDRESS (Include Zip Code) ATTN: AMSEL-ED-TM Fort Monmouth, NJ 07703-5023	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	